INTEGRATED VISION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to an integrated vision system that provides crew on vehicle with views of high visibility even at actually low visibility.

Vehicles, for example, aircraft are provided with a vision system having image sensors such as an infrared camera, a milli-wave radar and a laser radar. The vision system offers a driver or pilot with artificial pseudo-views generated based on view data collected by the image sensors at low visibility at night or in bad weather and three-dimensional (3-D) map data stored in the system for safety.

Japanese-Unexamined Patent Publication No. 11-72350 discloses generation of pseudo-views using wide-area geographical data based on 3-D map stored in memory and data on obstacles such as high-voltage electrical power lines, skyscrapers and cranes and displaying pseudo-views and actual views overlapping with each other on a transparent-type display mounted on a helmet of a pilot.

View data collected by the image sensors such as an infrared camera, a milli-wave radar and a laser radar are, however, not sufficient for a driver or pilot. Moreover, 3-D map data cannot follow actual changing geographical conditions. Pseudo-views generated based on these data therefore do not meet the requirements of a driver or pilot.

In detail, infrared cameras can be used at certain level of low visibility, particularly, can generate extremely clear images at night, however, lack in reality, perspective and feeling of speed due to monochrome images.

Milli-wave radars can cover relatively long rage even in rainy weather, thus useful in image displaying at low visibility, however, cannot generate clear images due to wavelength extremely longer than light, thus not sufficient for a driver or pilot.

Laser radars have an excellent obstacle detecting function, however, take long for scanning a wide area, thus

revealing low response. For a narrow scanning area, they provide relatively clear images, but, narrow views for a driver or pilot, thus not sufficient for safety.

Generation of images of scenery in wide range of sight which could be viewed by a driver or pilot is useful. Such image generation requires decision of degree of risk of collision based on comparison among geographical data, obstacle data and vehicle positional data (longitude, latitude and altitude). These data, however, may not match actual land features and obstacles. Such image generation thus has a difficulty in covering newly appearing obstacles and requires a lot of confirmation of safety.

SUMMARY OF THE INVENTION

A purpose of the present invention is to provide an integrated vision system that offers crew on a vehicle with almost real pseudo views at high visibility like in a good whether even at low visibility with detection of obstacles to the front for safe and sure flight or driving.

The present invention provides an integrated vision system comprising: at least one stereo-camera installed in a vehicle for taking images of predetermined outside area; a stereo-image recognizer for processing a pair of images taken by the stereo-camera to recognize objects that are obstacles to the front, thus generating obstacle data; an integrated view data generator for generating integrated view data including three-dimensional view data based on the pair of images taken by the stereo-camera and the obstacle data from the stereo-image recognizer; and an integrated image display for displaying the integrated view data as visible images to crew on the vehicle.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a block diagram of an integrated vision system according to the present invention; and

FIG. 2 illustrates displaying zones.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments according to the present invention

will be disclosed with reference to the attached drawings.

An integrated vision system 1 shown in FIG. 1 is installed in a vehicle such as an automobile, a train, and an aircraft. The system 1 offers integrated views to a driver or pilot generated as visible images of virtual reality at high visibility like in good weather even though actual visibility is very low in bad weather due to mist or fog, or at night.

Disclosed hereinafter is an embodiment in which the integrated vision system 1 is installed in an aircraft such as a helicopter that flies at relatively low altitude.

The integrated vision system 1 is provided with a stereo-camera 2 for taking images of forward scenery of a predetermined area, an image combining apparatus 10 and an integrated view displaying apparatus 20 as main components.

A pair of left and right images taken by the stereo-camera 2 are displayed on left and right viewing points of a pilot to generate three-dimensional (3-D) images giving perspective and feeling of altitude and speed to the pilot.

Moreover, the pair of left and right images are processed by stereo-image processing for calculation of data on (relative) distance to objects. The image and distance data are processed by image recognition processing for displaying obstacles as warning when the obstacles are detected on or in the vicinity of flight route.

The integrated vision system 1 is provided with a sight-axis switch 3 for varying an axis of sighting by which the stereo-camera 2 turns into the direction required by the pilot or other crew, a display-mode switch 4 for controlling the stereo camera 2 to halt displaying 3-D images, and flight data interface 5 for entering flight data such as speed, altitude, position and attitude of a helicopter.

The sight-axis switch 3 is useful to know beforehand the conditions of flight route to which the helicopter is to turn into or determine whether there is any obstacle on the route. The switch 3 in this embodiment is a manual switch to manually rotate the optical axis of the stereo-camera 2. Not only this, the stereo-camera 3 can be automatically turned into any direction

by detecting pilot's viewing point by a head-motion tracker 23, etc., which will be described later.

The stereo-camera 2 in this embodiment consists of two infrared cameras for generating extremely clear images particularly at night. The two infrared cameras are arranged with an optimum distance (base-line length) within an allowable range based on search range and distance accuracy for accurately detecting obstacles predicted under several flight conditions.

Flight conditions under which a pilot requires support of artificial view at general low visibility mostly include night flight or other flight very close to this. Infrared cameras having an excellent night vision function are useful in such conditions. Particularly, 3-D images generated by two infrared cameras offer virtual reality to a pilot with perspective and feeling of altitude and speed which cannot be achieved by a single infrared camera.

Other flight conditions can be covered by several types of image sensors such as an ordinary camera, an intensifier that responses faint light, active/passive milli-wave cameras exhibiting excellent transparency to mist and rain and sensitive CCDs, other than infrared cameras. These sensors can be selectively combined in accordance with cause of low visibility.

When relatively light-weight image sensors are used for cameras of the stereo camera 2, the base-line length for the stereo-camera 2 can be set by shifting both or either of cameras with the image sensors.

Heavy image sensors can be fixed with an objective lens mechanism installed in a tube of a periscope, the tube-length being variable for varying the base-line length.

The image combining apparatus 10 is provided with a stereo-image recognition processor 11 for recognizing obstacles by processing left and right images from the stereo camera 2, a geographical image generator 12 for generating 3-D geographical images of scenery which could be viewed by a pilot or crew based on view-point data sent from the head-motion tracker 23 which will be described later and data from the flight data interface 5, and an integrated view generator 13 for generating integrated

views which are combination of 3-D view data of left and right images from the stereo-camera 2, obstacle data from the stereo-image recognition processor 11, geographical data on wide view from the geographical image generator 12 and data from the flight data interface 5.

The stereo-image recognition processor 11 is provided with an image database 11a that stores several types of 3-D data for recognizing and displaying several types of obstacles, etc.

The geographical image generator 12 is provided with a 3-D digital map 12a that stores wide-area geographical data obtained by aerial survey or from satellites.

The integrated view displaying apparatus 20 is provided with a head-mount display (HMD) 21 to be mounted on a helmet of the pilot or crew and having a transparent-type display such as a transparent-type liquid-crystal display panel by which a pilot or crew can view actual scenery through integrated views from the integrated view generator 13, a display adjuster 22 for adjusting intensity and contrast of integrated views, and transparency to the actual views on the HMD 21 so that the pilot or crew can observe the overlapped actual views and integrated views in a good condition, and the head-motion tracker 23 for tracking the head position and attitude of the pilot or crew to output view-point data of the pilot or crew.

A pair of left and right images taken by the stereo-camera 2 during flight are sent to the integrated view generator 13 as 3-D images and also to the stereo-image recognition processor 11 for detecting forward obstacles.

The stereo-image recognition processor 11 processes the left and right images from the stereo-camera 2 by stereo-matching processing to obtain correlation between the images, thus calculating distance data by triangular surveying based on parallax to the same object, the position of the stereo camera 2 and its parameter such as focal length.

Data stored in the image database is accessed based on the distance and image data for recognizing obstacles, any objects that would block flight. The integrated vision system 1 installed in aircraft, for example, helicopters that fly

relatively low altitude recognizes structures such as pylons and skyscrapers or other aircraft, etc., in forward view during night flight. When the system 1 also recognizes high-voltage electrical power lines in the image data under recognition of pylons, it generates obstacle data that symbolizes or emphasizes the power lines and send the data to the integrated view generator 13.

Accordingly, when the integrated vision system 1 recognizes pylons, high-voltage electrical power lines and skyscraper, etc., in forward view via the stereo camera 2, it immediately warns the pilot of those structures as obstacles that could collide with so that the helicopter immediately takes an evasive action.

The present invention therefore offers high safety flight or driving without determination of degree of risk of collision by comparing stored positional data such as longitude, latitude and altitude with actual flight data in 3-D digital map.

The geographical image generator 12 performs coordinate-conversion of aircraft data such as speed, altitude and attitude and flight positional data input via the aircraft flight data interface 5 onto viewing points of the pilot or crew input from the head-motion tracker 23. The generator 12 further retrieves the converted data from the 3-D digital map 12a as 3-D geographical images which could be viewed by the pilot or crew and sent the 3-D images to the integrated view generator 13. The 3-D images are geographical data wider than actual scenery in forward view, for example, a row of mountains in the distance which will not be directly connected to safety against collision. These 3-D geographical image data can been seen as almost real scenes based on 3-D display generated by computer graphics with geographical information such as place names, lakes, loads and rivers if necessary.

The 3-D geographical image data may be generated from images detected by a wide milli-wave radar instead of the 3-D digital map 12a.

The integrated view generator 13 receives 3-D image data of left and right images taken by the stereo-camera 2 controlled

by the sight-axis switch 3 and also the obstacle images generated by the stereo-image recognition processor 11. The generator 13 also receives wide peripheral geographical images generated by the geographical image generator 12.

The integrated view generator 13 combines the obstacle and peripheral geographical images with image processing such as adjustments to resolution, intensity, contrast and color, and also edge-blending under the control of the display-mode switch 4, to generate natural images with no visible joints of combination as integrated view data.

The integrated view generator 13 combines the integrated view data with flight data such as speed, altitude, position and attitude sent from the flight data interface 5 if necessary, and send them to the HMD 21.

At high visibility such as a good weather, the stereo camera 2 may be turned off so that integrated view data not 3-D images of the stereo camera 2 but the obstacle data and other data, if necessary, are sent to the HMD 21.

FIG. 2 illustrates viewing zones covered by the HMD 21 with the integrated view data processed as disclosed above.

A viewing zone surrounded by a dashed line is used for displaying the forward view data with obstacle data from the stereo camera 2. Another viewing zone surrounded by a dotted line but outside the dashed line is used for displaying the wide-area view data of 3-D geographical images.

The pilot or crew can see actual scenery from a cockpit 30 through windows overlapping with the integrated views while watching indicators on the cockpit, thus the pilot or crew can see to indicated data in addition to those displayed on the HMD 21.

As disclosed above, the integrated vision system 1 according to the present invention offers a pilot or crew with 3-D images almost real in perspective, altitude and speed based on left and right images taken by the stereo camera 2 even at a low visibility, which cannot be achieved by a single camera.

The integrated vision system 1 further processes the left and right images from the stereo camera 2 by stere-image

processing for image recognition using distance data to detect obstacles on or in the vicinity of flight rout and displays the obstacles as warning.

The integrated vision system 1 according to the present invention thus offers pseudo-visual flight even at row visibility to support a pilot for safe and sure flight in regular service or emergency.

Three-D images may not be required at high visibility, however, detection of obstacles for warning by stereo-image recognition processing achieves further safe flight.

Three-D image display of forward views and obstacle detection/warning are performed by the stereo-camera 2 with no sensors for respective functions. The integrated vision system 1 according to present invention thus can be structured as a reliable and light system at a low cost.

As disclosed above, the present invention offers crew on a vehicle with almost real pseudo views at high visibility like in a good whether even at low visibility for safe and sure flight or driving with detection of obstacles to the front.

It is further understood by those skilled in the art that the foregoing description is a preferred embodiment of the disclosed system and that various change and modification may be made in the invention without departing from the spirit and scope thereof.